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HORTICULTURE AND BOTANY

By JOHN CRAIG and J. M. VAN HOOK.

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CORNELL UNIVERSITY, ITHACA, N. Y., NOV. 28, 1902.

TO THE HONORABLE COMMISSIONER OF AGRICULTURE,

ALBANY, N. Y.

Sir: This bulletin is submitted under Chapter 430 of the Laws of 1899. It is prepared jointly by Professor Craig, in charge of field investigations in horticulture, and Mr. J. M. Van Hook, assistant in the department of Botany.

The bulletin describes an apparently new enemy of the apple. While the fungus may not appear to an alarming extent another season, it is well that fruit-growers should be informed in regard to its nature and the best means of controlling it. This may be regarded as a preliminary investigation.

I. P. ROBERTS,

Director.

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PINK ROT

AN ATTENDANT OF APPLE SCAB.

The purpose of this bulletin is to draw attention to a very destructive enemy of the apple accompanying and following apple scab. Unusual difficulties are peculiar to abnormal seasons. The summer of 1902 was without question abnormal. The rainfall was excessive and continuous. Many forms of fungous diseases are greatly encouraged by wet weather. Apple scab (*Fusicladium dendriticum* Fckl.) is among this number; monilia, the soft rot of the plum and peach, downy mildew and black rot of the grape also flourish during periods of atmospheric humidity. The fruit-grower is enjoined to spray, but if it rains every day it is difficult to carry out the injunction. Nevertheless spraying rarely pays better than during a rainy season. The man who sprays "rain or shine" is the man who insures his crop against fungi and insects. The experience of the season fortifies the truth of this statement. Scab, or black spot, is the principal fungous enemy of the apple in Western New York. It is destructive of itself, but when it acts as an agent for the introduction of an organism which destroys the market value of the apple much more swiftly, the scope of its injurious effects is greatly widened. The damage to the apple industry of New York State chargeable to apple scab is enormous. This fall the scab was somewhat lost sight of in Western New York by the appearance of a destructive fungus which for a time quite outrivalled it. The Station was advised of the appearance of this new trouble by Orleans and Wayne County growers early in October.

FIG. 36.—*A lopsided form caused by scab.*

Apple scab does not produce rot. Its presence checks the growth of the apple, often making it lopsided, dwarfed or gnarled, (Fig. 36). The tissues beneath the scab become dry and "punky." This is very distinct from the appearance of the rot treated in the following pages.

This secondary parasite appears only on apples infested with scab, first as a thin gray mildewy looking coating, always thicker around the margins of scab spots than elsewhere. It was abundant on unpicked and unsprayed Greening, Baldwin, Fall Pippin, Pound Sweet, Nonsuch, Pumpkin Sweet, Spitzenburgh and Twenty Ounce, but did not cause the decay of the fruit as a rule until sometime after it was barreled or had remained for a while in piles on the ground. Under these conditions it developed rapidly, forming at first whitish rings around the scabs, later covering the whole scab spot with a pinkish white coating. This stage is rapidly followed by the partial or complete collapse of the tissues beneath the spots. Although it is not destroyed, the fruit is at once rendered unsalable and a few of these affected areas quickly destroy an apple. The mycologist finds that this enemy has the following characteristics (pp. 162-166) :

CHARACTERS AND GROWTH OF THE PINK FUNGUS.

General appearance on apples.—This fungus which has been so destructive to apples in many parts of New York State this year, is very characteristic in its appearance on the apple. It is frequently called by fruit-growers, "the pink fungus," from the color of the spots as the fungus matures.

If we examine an apple affected by this disease in its more advanced stage, we notice one or more pink spots which are usually more or less circular and sunken. Plate I, d, from a photograph, will show this stage. Around the fungus and in the edge of the sunken portion, the skin is brown.

How it begins and spreads on scab spots.—If we examine these spots at an earlier stage, we will usually find a circular white patch of mould, or still earlier, perhaps a ring of mould about a darker scab spot. Plate I, c, is from a photograph at this stage.

When the scab fungus itself, first takes hold of the apple, it grows beneath the skin, and as it matures, the skin is ruptured and the edges left somewhat upturned. It is near the upturned edge that the "pink fungus" so often makes its beginning, forming a ring of mould. The entire scab spot however, is usually covered with a white mould. This gradually changes to a pink or rose-color. This color is due to the entire spot becoming dusted with the pale rose-colored spores.

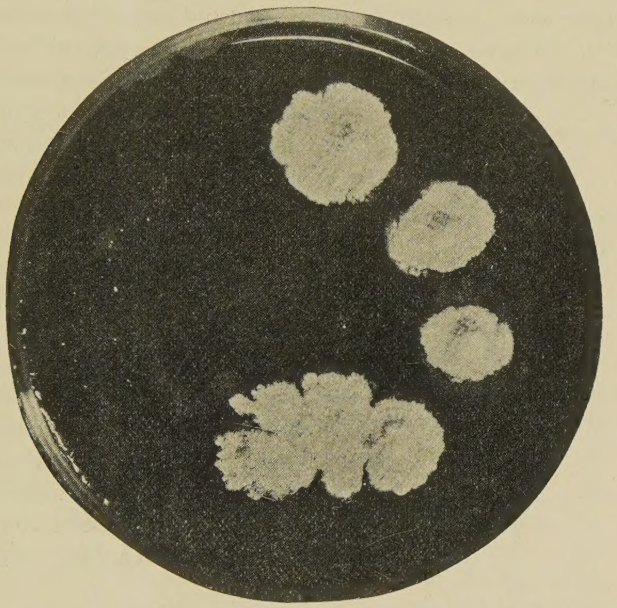


FIG. 37.—*Pure culture of "pink fungus" growing in petrie dish.*

Effect on apples.—The first change in the appearance of the apples, is that the skin or epidermis turns brown around the spots. This gradually extends out in all directions so that the various spots merge into each other, covering large areas, or the entire surface of the apple. As the spots increase in size, they also sink. The sinking may be due not only to the dissolving of the solid parts of the apple by the fungus, but also to the evaporation of water through the spots. Not only does the skin of the apple in the edge of the sunken spot, turn brown, but the flesh beneath is similarly colored, and is bitter to the taste.

Is the "pink fungus" a parasite?—In order to determine the method of attack this fungus, apples were inoculated with a pure culture of the spores. These spores were placed on the scab spots which were free from the "pink fungus;" also on sound apples. Other apples free from the fungus spores were kept as checks. The apples were easily inoculated through the scab wounds, but the sound apples, as well as the checks were not affected. Apples which were perhaps already affected with the fungus, were thoroughly disinfected and subjected to the same tests with the same results. The fungus developed in the tissues of the apple only where a wound had previously been made.

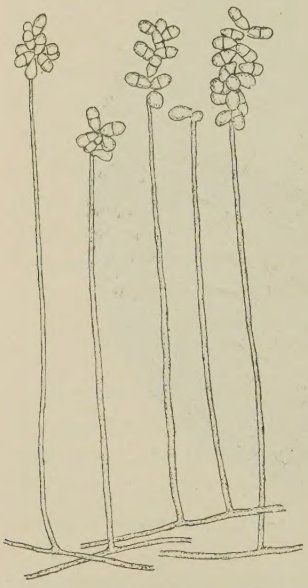


FIG. 38.—*Spore-bearing stalks.*

Conditions favoring its growth.—Like most fungi, considerable moisture is necessary to its vigorous growth; this it finds among those apples which have been piled in heaps, or put into tight barrels or in various places of ordinary storage, where the moisture is conserved.

Greening and Baldwin are both very susceptible to the fungus, especially the former. In looking in the Ithaca markets for Greenings affected by the scab, for experimental purposes, none were found that were not also affected with the "pink fungus."

Structure of the fungus.—An examination of the fungus under a low power of the microscope shows it in Fig. 38. Here we see slender stalks arising from the thread-like portion of the fungus. This thread-like structure is known as mycelium. The stalks are about $\frac{1}{125}$ in. in height, and bear at the upper end several spores collected in an irregularly rounded mass. We often find several of these stalks arising from the same thread of mycelium not far apart, and perpendicular to it. The threads have many cross-walls, but the stalks have not. The mycelium is distributed in the tissues of the apple. It forms an intricate net-work, so that the stalks arising from the threads are very numerous and generally cover the entire scab spot.

Formation of spores.—The spore-bearing stalks arising from the mycelium form the fruiting portion of the fungus. They appear at first as mere protuberances on the threads, then rapidly elongate. The first indication of a spore is the swelling of the upper end of the stalk (Fig. 39 (2)). A cross-wall then cuts off this end to form the first spore. Before the spore is fully mature, an enlargement takes place on one side of the stalk just beneath the spore, and its growth turns the first spore in the opposite direction (Fig. 39–(5)). It is often turned at right angles to the stalk. Thus, only the first spore is borne erect, and that only in the beginning. Other spores are formed similarly to the second one, until loose heads of ten to thirty spores are frequently observed (Figs. 38, 39–(7)).

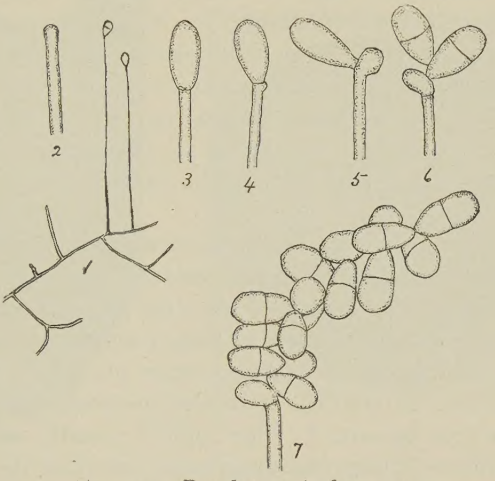


FIG. 39.—*Development of spores.*

The spores fall off very easily, and a mount in water usually shows the stalk with one, or at the most, two spores. This stalk consequently looks, in shape, like an umbrella handle or golf-stick The fruiting stalks and threads of mycelium are white and hyaline. The spores are oblong-obovate (Fig. 39–(7)). They are slightly constricted near the middle and here divided by a cross-wall into two cells. They are pale rose in color, hyaline and smooth.

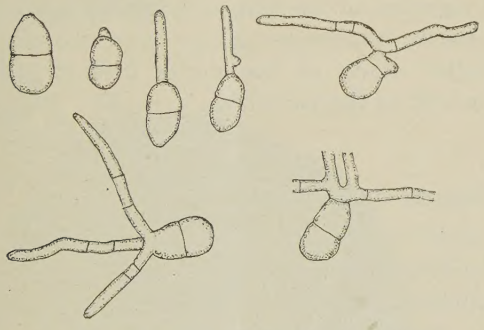


FIG. 40.—*Germination of spores.*

Germination of spores.

Spores placed in a drop of almost any culture medium, or in water, germinate very readily, and send out a tube which soon becomes very much branched and extends in every direction (Fig 40). This tube may arise from one or several places on the surface of the spore; but the most common point of germination seems to be at the more pointed end. When the spores fall on the scab spots of the apples, they germinate, under favorable con-

ditions, and the tube enters the tissues of the apples. It branches many times, penetrating the soft pulp of the apple in every direction, disorganizing it.

What the fungus is—This fungus is an old one, familiar to all students of the fungi. It has recently appeared, however, in a new role, in that it has caused such a wide-spread destruction of apples. It is technically known as *Cephalothecium roseum* Cda., and was first described and figured by Corda about the year 1836 It was found growing on an old decayed fungus in Austria and has since been collected on various kinds of decaying vegetable matter.

It has always been regarded as strictly saprophytic (*i. e.* growing on dead or decaying matter) and may be found throughout the warmer season of the year growing on various decomposing substances. Indeed it would not be able to destroy apples as it does, unless an entrance were provided. Since it is not able, alone, to enter the tissues of the host, it should not be regarded as a true parasite.* The apple is usually well matured before the disease makes its appearance, and then the fungus simply enters a wound and uses the pulp as a nutrient medium. It seems better to place it among those fungi which are wound parasites.

The sudden appearance of this fungus as an injurious one, when it has always been regarded of no economic value because of its purely saprophytic habits, impresses upon us more strongly the urgent need of a better study of the entire field of the fungi—the saprophytic as well as the parasitic.

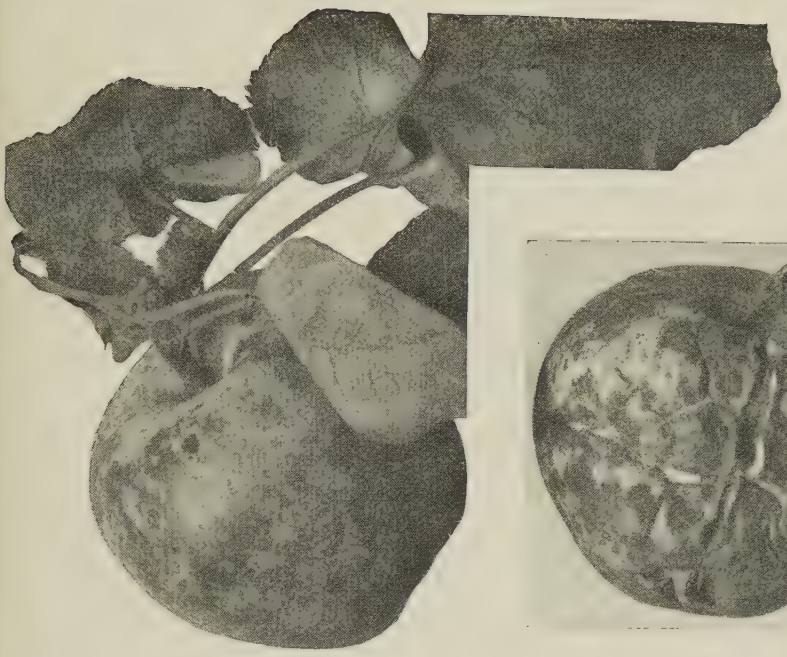
J. M. VAN HOOK.

STATEMENTS OF GROWERS.

Nearly every variety more or less affected ; some very badly. It would be difficult to estimate the percentage. There is, however, very little of the ordinary "soft rot," and piled apples are keeping well. CHAS. A. HOAG, Lockport, N. Y.

My apples were not seriously affected. This comparative immunity I attribute to heavy spraying. We put on a large

*Just as this bulletin is going to press, a brief article has appeared in Science [Sci. XVI, p, 747] in which the writer, H. J. Eustace of the N. Y. Agr. Sta. at Geneva, considers it a true parasite.



a b

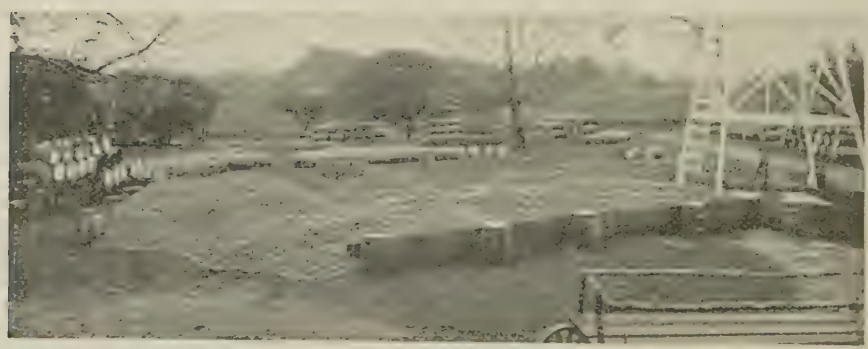
Fruit affected by scab only. a, first stage. b, final stage.

c d

Fruit affected by scab and pink fungus, early and late stages.

PLATE I.

Pink rot encouraged by custom of piling in orchards.



Large heaps generate considerable heat.

PLATE II.

amount of material with a gasolene engine at 125 pounds pressure and the fruit showed so much russet early in the season that I was greatly dissatisfied with it. In harvesting we found that we had a superior quality practically free from scab except the Greenings; even of that variety we were able to put more than half in a fancy grade free from scab. One row containing Baldwin, Greening and Mann was sprayed on one side only. That side was clean. The fruit on the unsprayed side was specked and mostly worthless.

W. T. MANN, Barker, N. Y.

The fruit of nearly every orchard in this vicinity is more or less affected, some of them to the extent of 90 per cent. Duchess was not injured; and Russets and Hubbardston to a less extent than other varieties. My observation convinces me that orchards that were sprayed late in the season are in decidedly the best condition. In one case an orchard sprayed on July 15, produced a fine crop of clean fruit—the best in the section.

L. A. BRADLEY, Lake Road, N. Y.

The disease developed very rapidly with me as soon as the apples were confined in barrels or bins or piled on the ground.

B. J. CASE, Sodus, N. Y.

AN ATTENDANT OF APPLE SCAB.

This disease is, then, an attendant of apple scab. It has not been proved that it will attack healthy fruit. The supposition is that it only infests apples already parasitized by apple scab. If this is the case, the first and obvious thing to do is to prevent apple scab. Fruit-growers are familiar with the method of treating this disease. The treatment is preventive. It is not remedial in the full meaning of the term. The tree is covered with a protective coating of Bordeaux mixture which prevents the germination of the spores from which the parasitic plant, known as the apple scab, is developed. When the parasite becomes established remedies are relatively ineffective. It is true that a scab spot on an apple will cease to enlarge if thoroughly covered with Bordeaux mixture. But no amount of doctoring will fully repair the injury.

PREVENTIVES OF PINK ROT.

The essential thing is to secure healthy apples. These are obtained by good tillage, proper pruning and careful spraying. Apples free from scab may be counted upon to be free from pink rot. Orchards in which this new trouble was prevalent this year, should be sprayed next spring before the buds swell, with copper sulphate solution—one pound to twenty-five gallons. The copper sulphate should be followed with Bordeaux mixture when the flower buds swell ; another application should be made soon after the blossoms fall, and at least one more after an interval of ten days. So much for what should be done next spring.

Spraying difficulties of the season.—While the recommendation to spray is in order and the efficacy of the practice is backed by reliable experience, yet spraying did not appear to be wholly satisfactory the past season. In many instances sprayed orchards lost their foliage, and in some cases to a greater extent than those unsprayed. Unquestionably the spray injured the foliage in many instances, but there is also undoubted evidence that it greatly improved the quality of the fruit, so that the final outcome was on the side of the sprayed trees. It seems fairly certain, and this assertion is based on experiments conducted on the station grounds at Cornell, that Bordeaux mixture of the regular formula, prepared either by weight or by ferrocyanide test, burned the foliage of all apple trees to a greater or less extent in the wet belt of Central and Western New York this year. It has also come under my observation that wherever lime was added in excess of the required amount the injury was correspondingly lessened. In one large orchard where as much lime was used—nearly three times the ordinary amount by formula—as could be forced through the nozzles, no injury to foliage occurred, and the crop was one of the finest in Western New York. Lime is used to neutralize the acidity of the copper sulphate solution. It has no special fungicidal power (though it probably has some), but it helps to hold the vitriol on the tree, and when freely applied forms a protective coating on the twigs and branches. The experience of the season warrants the recommendation that in *rainy seasons at least twice the regular amount of lime should be used in making Bordeaux mixture.*

Spraying should also be done with an extra degree of thoroughness. At any rate, use as much lime as can be forced through the nozzles.

WHAT CAN BE DONE NOW?

Experiments are in progress at the Cornell Experiment Station which are designed to test the practicability of disinfecting apples by dipping or fumigating in order to prevent the growth of this fungus. Samples have been dipped in solutions of copper sulphate and formalin, and have been fumigated with formaldehyde gas, and with vapor of sulphur. At this writing the formaldehyde gas treatment promises favorably

Mr. A. E. Stene, a graduate student, who has had charge of the experiments, reports as follows:

The experiments consisted in (1) dipping the apples in fungicidal solutions, and (2) in fumigating the apples in a closed receptacle.

For dipping, the solutions were prepared in three gallon quantities. The apples were put in gauze bags and immersed about 30 seconds. After the surplus liquid had drained off the apples were put in bushel crates and placed in the storeroom.

In fumigating, the apples were placed in a crate, and this together with the fumigating apparatus was covered with an inverted can holding about 4⅓ cu. ft.

One peck of apples was used for each experiment and one peck of each, Baldwins and Greenings was stored with the rest without being treated for the purpose of checking the results.

Nov. 5. Treatment with copper sulphate (Greenings only.)

No. I Solution contained 1 lb. copper sulphate to 100 gal. of water.
" II " " 1 " " " 150 " "
" III " " 1 " " " 200 " "

Nov. 6. Treatment with ammoniacal copper sulphate (Greenings and Baldwins). Fruit immersed as follows:

No. I Solution contained 5 oz. to 50 gal. water.
" II " " 4 " " " " "
" III " " 1 " " " " "

Treatment with formalin in solution.

No. I Solution contained 1 per cent formalin.
" II " " 2 " "
" III " " 3 " "

Nov. 7. Treatment with evaporated formalin. (Greenings only.)

The formalin was placed in an evaporating dish over an alcohol lamp and allowed to evaporate slowly. The apples were subjected to the vapor for 2½ hrs.

No. I, ¼ oz. formalin was used.
" II, ½ " " " "
" III, 1 " " " "

Nov. 12. Fumigation with formaldehyde lamp.

No. I treated for half an hour. About ¾ of an oz. of alcohol was consumed.

No. II was treated for ¾ hr. and about 1 oz. of alcohol was consumed.

Nov. 13. Fumigation with formaldehyde tablets.

One peck each of Baldwins and Greenings was fumigated for half an hour.

Nov. 18. Fumigation with sulphur. (evaporated.)

One peck each of Baldwins and Greenings was fumigated for half an hour. ½ oz. sulphur was used.

Results, Nov. 21.

There are, as yet, no marked differences in treated and untreated samples of the Baldwins. The Greenings that were treated with solutions of copper carbonate and copper sulphate are in no better condition than those not treated. Those treated with evaporated formalin are rotting badly in spots affected by fungus. Decay is also going on in places where no sign of fungus is seen. The pink rot fungus is not fruiting as freely as in the check.

Greenings treated with 1 per cent and 2 per cent solution of formalin are in good condition and show very little evidence of rotting, or of the fruiting parts of the pink rot. Those treated with 3 per cent solution are not as free from fungus.

Greenings treated with formaldehyde gas from lamp are also in good condition. Those treated with gas from tablet are not in quite so good condition as those treated with gas from lamp.

Low temperatures.—The growth of the organism may be checked by placing the fruit in cold storage if the temperature is kept near freezing. Scabby apples kept in a temperature of 32 degrees Fahr. for a period of four weeks were examined but showed no signs of the fungus, while samples from the same trees left in orchard in barrels, or in heaps on the ground, were utterly ruined for commercial purposes. On bringing the fruit out of storage the rot will in all probability again develop. The warmer the storehouse the more rapidly will the apples rot. Ventilation is important. Tight packages are usually best where the temperature is not under control. Piling apples on the ground or in bins will encourage the pink rot.

GENERAL RECOMMENDATIONS.

1. Spray diligently to prevent apple scab because the presence of the scab appears to be necessary to the development and growth of this secondary fungus, pink rot.

2. If there are signs of the presence of pink rot as harvest time approaches, spray the trees and fruit before picking, with copper sulphate at the rate of one pound to two hundred and fifty gallons of water, or with ammoniacal copper carbonate, the standard formula--five ounces dissolved in two quarts of ammonia and diluted to fifty gallons of water. When scab is prevalent a late spraying will pay.

3. Grade the fruit with the utmost care. Reject all spotted specimens. Scabby or wormy apples should not be barreled unless they are to be placed in cold storage, and then they should be separated from sound stock. The apple scab that appears only as a tiny patch at packing time may destroy the salability of that particular apple in two months' time if the temperature of the storage chamber should range above 45 degrees Fahr. These destructive diseases continue to grow on the apples in the barrel in ordinary storage.

4. Cold storage will retard or check pink rot and apple scab. The destructive organism will not grow at such temperatures as should be given apples in storage, viz. from 32 to 34 degrees. When the fruit is taken from storage, decay will undoubtedly go on, with perhaps increased rapidity.

5. The indications are that stock for the evaporator could be profitably fumigated with formaldehyde gas.

6. The lesson of the year is that fungi which attack the apple are favored by a rainy season and that spraying which is important every season is doubly so during summers characterized by excessive humidity.

JOHN CRAIG.

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